State of EOS, CERES, NPOESS

26th CERES Science Team Meeting

May 14, 2002

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State of NASA / EOS

- New NASA Administrator (O' Keefe) has a vision that seems to include a strong Earth Science program. Proof will be in future budgets. Current outlook has been flat funding.
- Sean O' Keefe views NASA from an OMB management perspective: performance and societal relevance first, technology second.
- Bush administration review of future NASA Earth Science Missions still underway.
- NASA Earth Science met ~ 85% of performance metrics in 2001: similar to Space Science.

State of Climate Research

- Tentative new Science and Technology Management Structure (following chart)
  - Good news: something being done shows concern
  - Bad news: committee on top of committee looks like a good way to keep policy and science at arms length.
  - Bad news: great potential for multi-agency gridlock
  - Bad news: no discussion of substantial new funding
  - Good news: too early to draw firm conclusions
- Overall: this bears little relationship to a "climate mission" organizational structure: too diffuse.
- Energy technology funding (renewable energy, fuel cells, etc) appears to be top priority, climate science second.


Draft!

Status of CERES Project

- FY02 and FY03 funding dropped 5%: but not nearly as bad as we feared.
  - Still 5-10% issues between LaRC management and NASA HQ on the best way to handle overhead costs.
- Will cause some schedule slips in data products
- To date, CERES funding for algorithms/science is about 30% less than planned, and the advanced data products are about 30% later than planned.
- EOS Recompetition Schedule:
  - Anticipate science/analysis NRA release August 1, 2002
  - Proposals due 3 months later
  - Successful proposal funding starts June, 2003.
- Similar schedules for Algorithm/Maintenance RFP.

Status of CERES Project

- Aqua launched May 2, 2002! more to follow….
- New papers coming out in GRL, J. Climate, Science, and others.
- In Terra data products review, Ghassem indicated that he was getting the most favorable comments from the science community on CERES products
- Status of next data products to be delivered will be covered in this meeting.
- Next Science Team meeting at GFDL Sept 17-19, 2002.

Status of CERES and NPP

- Proposals with Lockheed and TRW NPOESS teams for ERB (CERES-like) instrument and data products submitted to NPOESS in Feb/March. Under review with decision in August.
  - Not clear that NPOESS budgets can cover all instruments. An ERB measurement may or may not be high enough priority for a weather satellite system.
  - NPOESS has refused to accept climate data product requirements or archive requirements. Their budget is not capable of handling it. NOAA and NASA trying to provide these functions, but funding TBD.
  - Some NPOESS calibration/stability climate checks already being lost: VIIRS (MODIS follow on) has dropped lunar calibration/stability checks during critical design review.

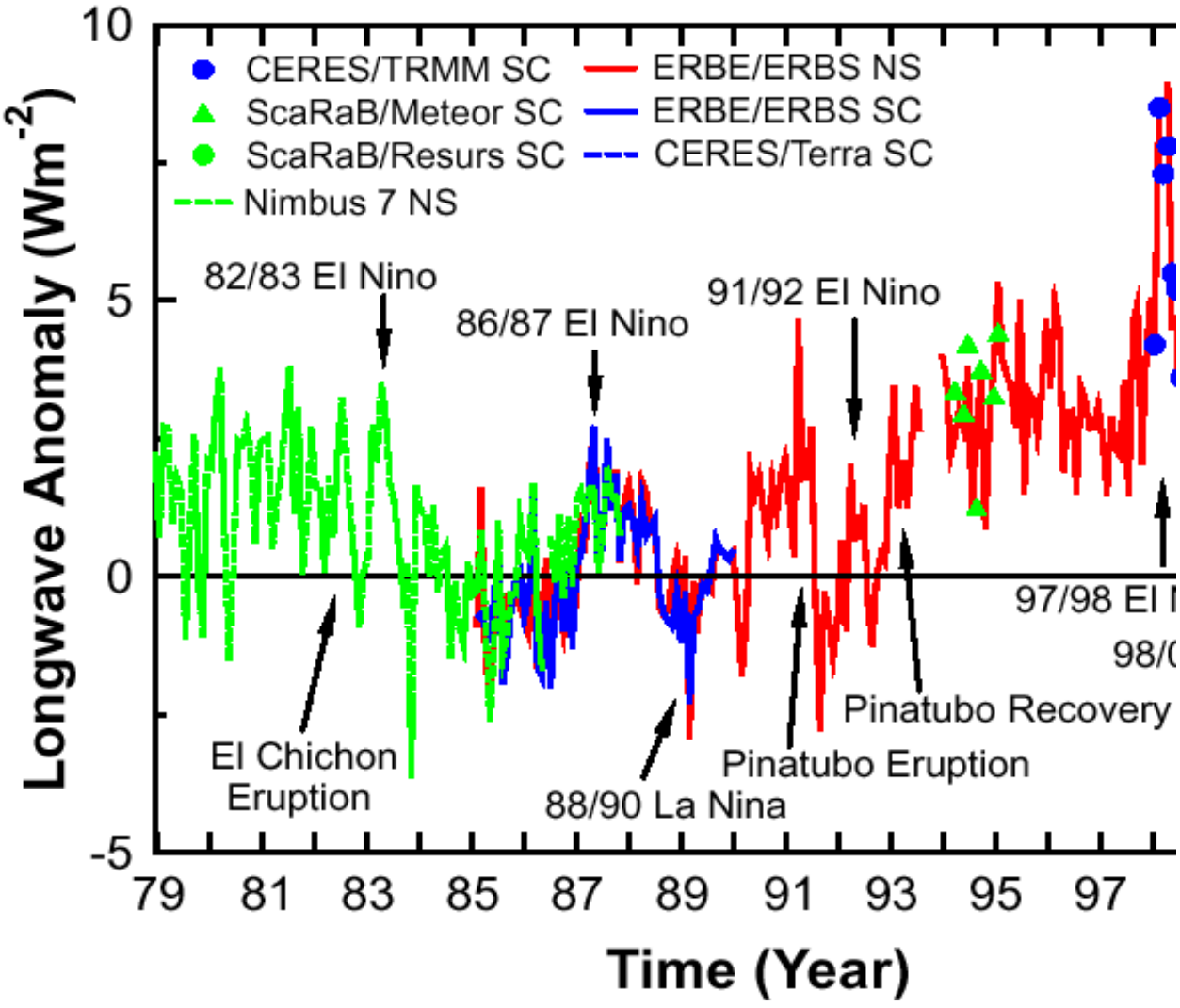
Status of CERES Project

- Still a small possibility (10%) to get CERES FM-5 gap filling instrument on the NPP (NPOESS Preparatory Project) mission.
- Provided following charts to science lead (Bob Murphy) on NPP in April to summarize the science, cost, risk issues.
- NASA/NOAA/NIST workshop on climate calibration and measurement strategies moved tentatively to Nov 5-7, 2002 (was late June).

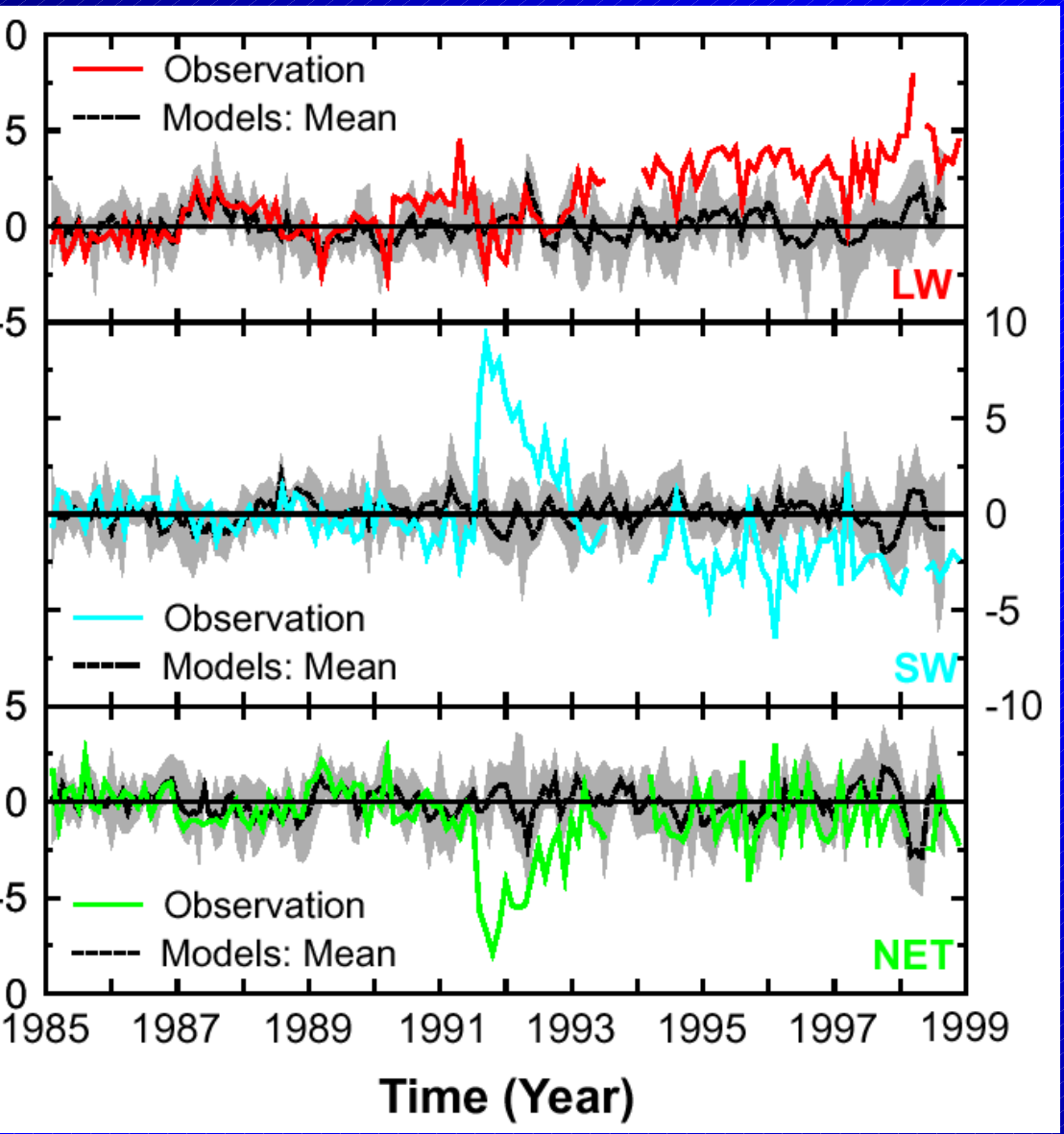
Why CERES on NPP? Science

- Clouds, aerosols, and radiation are the largest uncertainties in climate sensitivity, forcing.
- Confidence in climate model predictions requires improved ability to test prediction of large time/space scale anomalies: not only weather.
- Verifying climate surprise & climate model errors requires independent verification with different approaches:
  - CERES direct measured integrated energetics vs
  - MODIS/AIRS climate components + radiative models.
- CERES provides the only current climate quality data set for the SW and LW radiative energetics that drive climate.
  - Decadal climate signals in SW and LW for zonal mean are typically 1 to 3 W/m^2, and occasionally up to 8 W/m^2.
  - CERES absolute calibration accuracy ~ 1 W/m^2 (limit if gaps)
  - CERES stability for climate change ~ 0.25 W/m^2(limit if overlap)

An overlapping Earth radiation climate record 23 years from Nimbus 7 to Terra.



Observed Decadal Tropical Radiation Variation Exceeds Current Climate Models



LW: 1% = 2.5 W/m²
Emitted Thermal Fluxes

SW: 1% = 1 W/m²
Reflected Solar Fluxes

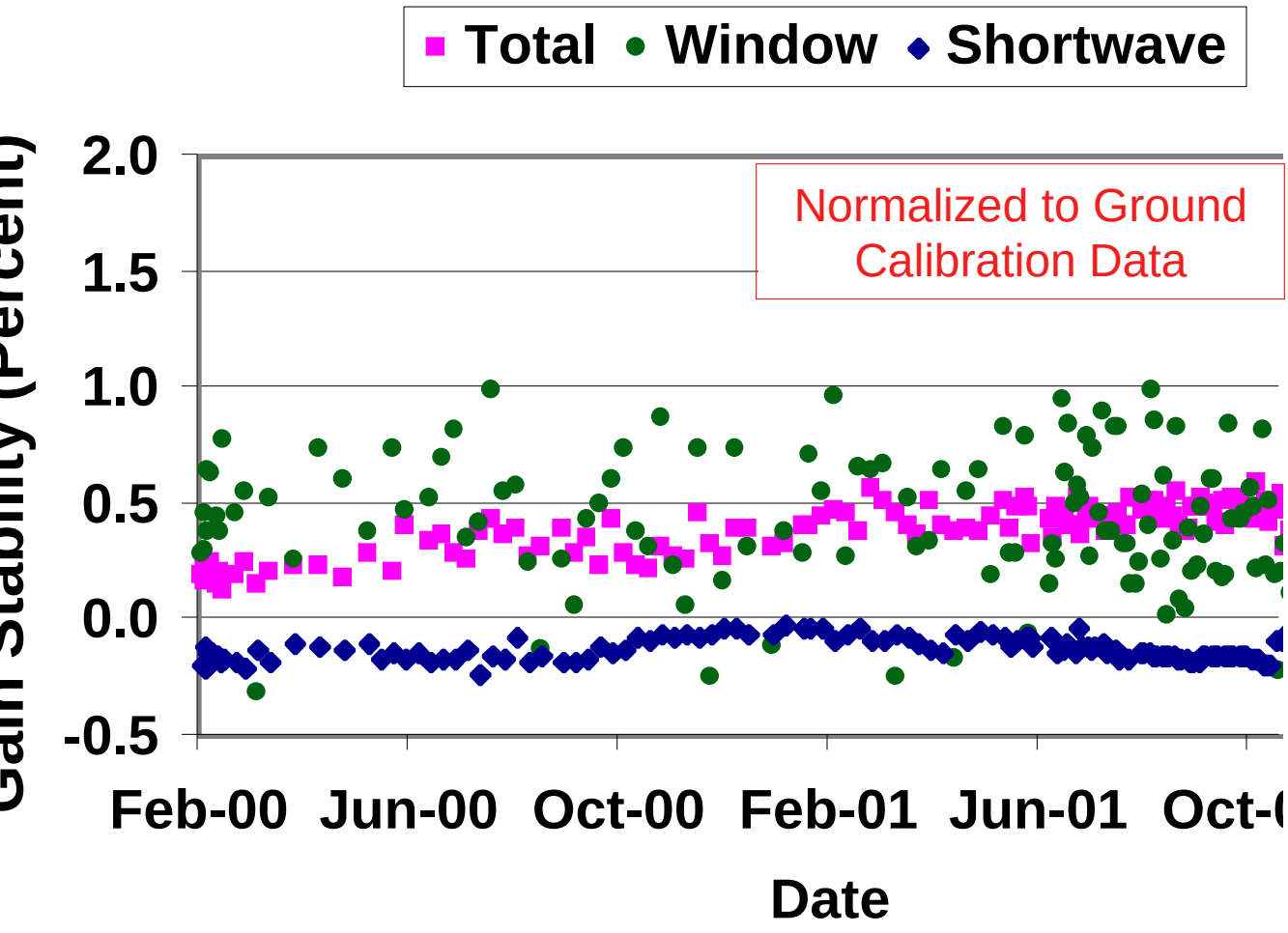
Net: Solar - SW - LW
Net Radiative Fluxes

Models less variable than the observations
- missing feedback?
- missing forcings?
- clouds physics?

Why CERES on NPP? Science

- **Why is CERES unique as a climate measurement?**
  - **The only stable measurement of SW reflected radiation.**
    - **Narrowband imager calibrations change 1 to 10%/yr**
    - **Cannot determine cloud/climate feedback without SW flux changes.**
    - **Significant SW flux changes are 0.2 to 3% / decade.**
    - **To date, all three CERES instrument SW channels have shown no gain change detectable at 0.1% over 2 yrs in orbit.**
    - **Unique ability to verify stability of entire optics/filter/detector/electronics throughput by turning small CERES telescopes to directly observe lamps, blackbodies and solar diffusers.**
  - **CERES is the integral constraint on radiative energetics: the absolute minimum dependence on radiative theory.**
  - **Narrow spectral instruments like MODIS & AIRS provide the surface/atmosphere components which along with radiative theory can be used to independently test CERES energy changes and pin down cause/effect.**

Terra/CERES Flight Model 1
Lifetime Radiometric Stability
Determined with the Internal Calibration Module



CERES Calibration/Stability Performance
TRMM and Terra

	Ground to Flight Consistency (%)			On-orbit stability (%/year)			
	TOT	SW	WN	SW/TOT	LW/TOT	SW	WN
TRMM/PFM	0.13	0.26	0.14	<0.1	<0.1	<0.1	0.22
Terra/FM1	0.20	<0.1	0.48	<0.1	0.2*	<0.1	<0.
Terra/FM2	0.12	<0.1	1.3	0.60*	0.36*	<0.1	<0.
Aqua/FM3	TBD						
Aqua/FM4							
FM5							

maining small drifts corrected using on-board calibration to ~ 0.

Why CERES on NPP? Climate Record

- **Key climate data record:**
  - **24-yr overlapped record of broadband radiation data from Nimbus 7 in 1978 to CERES Terra in 2002.**
  - **Terra/Aqua CERES until 2008 (6-yr life: fuel limited by new de-orbit requirements: 150kg of fuel: 2/3 of total)**
  - **NPOESS ERB (CERES follow-on) nominal in 2011.**
  - **GAP in 2008-2011 planned NASA/NPOESS measurements**
  - **Early CERES data is best absolute calibration in EOS: 0.5% in LW, 1% in SW: roughly 1 to 1.5 W/m^2.**
  - **Early CERES data appears capable of 0.1% stability: allowing signal significance at 0.1 to 0.2 W/m^2: 5 to 10 times better than non-overlapped data limited by absolute calibration:**
    analogous to the solar constant overlap requirement.

What is the Radiation Budget Gap Risk?

Probability of Aqua beyond 2008: **< 10%**

- Limit is safety requirement to de-orbit Aqua after 6 years.

Probability of Terra beyond 2008: **< 20%**

- Limit is whether a decision is made to de-orbit, even though the mission is formally "grandfathered". Safety issue.
- If avoid de-orbit, then probability thru 2011 rises to 70%.

Nominal NPOESS launch: 2011: leaves 3 year gap.

Probability of Megha-Tropiques fill 2008-11: **~ 50%**

- 2 to 3 year mission design. Launch 2007, 50% thru 2011.
- 20 degree orbit, so only tropical coverage.

Probability of GERB filling 2008-2011: **< 20%**

- 1 to 2 year instrument life (de-spin mirror bearings)

Why CERES on NPP? Cost Savings

- Major Cost Savings are Possible using stored CERES FM-5.
- Flying CERES FM-5 on NPP instead of a separate smallsat saves:
  - $25-30M launch (Pegasus) plus satellite (smallsat)
- NASA Terra/Aqua allow NPP and NPOESS to fly 1 CERES instrument in 1 orbit for angle and time sampling.
- A 30-year record (by 2008) of climate quality overlapped radiation data will be ended in 2008 (Aqua must de-orbit).
- There is no U.S. or international climate observing system to pick up this measurement: unlike the global weather data
  - ESA Geostationary Earth Radiation instrument is 1-2 year instrument lifetime on 7 year missions: unable to cover 3-4 year gaps (2008 to 2011).
  - CNES/Indian Megha-Tropique launches last ScaRaB copy in 2007 with 2-3 year lifetime. 50% chance to cover data gap.

Why CERES on NPP: Bottom Line

- **Without CERES on NPP:**
  - **Risk of losing global systematic new EOS generation of radiation budget data in 2008-2011: 100%.**
  - **Risk of losing overlapping intercalibration tie for all systematic radiation data dating to 1978: 50%.**
- **CERES on NPP saves ~ $30M or more relative to using a smallsat to fill the data gap.**
- **Cloud/aerosol/radiation is the most uncertain feedback/forcing in the climate system: key climate data.**
- **Loss of an overlapped systematic radiation record from Nimbus 7 through NPOESS would seriously hamper decadal climate study.**
- **Estimate lost "science" value at 20% of EOS investment in this data record: ~ $100M.**

CERES Instrument Characteristics

- **Mass** — **50 Kg**
- **Power (average)** — **55 Watts**
- **Duty Cycle** — **100%**
- **Data Rate (average)** — **20 kilobits/sec**
- **Data Rate (peak)** — **20 kilobits/sec**
- **Size** — **60 x 60 x 60 cm**

Unlike Terra and Aqua, NPP would fly a single CERES Instrument (FM-5) using the morning orbit angular dependence models (ADMs) developed using the 2nd Terra CERES instrument.

CERES: *Beyond ERBE-Like TOA Fluxes*

TOA Fluxes:

- Factors of 2 to 10 accuracy improvement (e.g. equator to pole hea
- First fluxes accurate as a function of cloud/aerosol: allow studies d*Radiation* / D*cloud or aerosol property.*
- Test climate models by cloud/aerosol type: not only monthly avg.

Surface/Atmosphere Fluxes:

- New accuracy using improved TOA flux constraint and merged imager cloud/aerosol data with broadband radiation data.
- Key for land/ocean studies, and resolution of anomalous absorption. Analogous to 4-D assimilation but for radiation.

Level 3 Gridded/Time Averaged TOA, Sfc, Atmosphere Fluxes:

- Merged geostationary 3-hourly sampling with low earth orbit broadband radiation: 3-hourly, daily and monthly averages.
- Factor of 2 to 4 accuracy improvement in daily average and monthly average fluxes.

A new generation of highly integrated climate data products

- Major steps in calibration, stability, vertical/angle/time sampling

CERES: *Beyond ERBE-Like TOA Fluxes*

Stability of CERES instrument design allows potential to reach 0.2% or 0.5 W/m^2 change detection: *but only with data overlap!*

- **Currently a gap from end of Aqua (2008) to start of NPOESS (2011).**

Reduced Cost for NPP era data:

- **Reduce from 2 CERES scanners for EOS to 1 for NPOESS**
  - **NPP uses Terra (am orbit) developed second scanner angular models**
  - **NPOESS uses Aqua (pm orbit) second scanner angular models**
- **Reduce from 2 EOS orbits to 1 for NPOESS**
  - **Ability to handle diurnal sampling developed by EOS CERES: combine broadband low earth orbit with 3-hourly narrowband geostationary.**

Using EOS CERES developed/validated algorithms and investme radiation data in the NPOESS era will be:

- **Improved Accuracy (factor of 2 - 10) (cal, angle/time sampling**
- **Reduced cost (factor of 4) (1 orbit, 1 instrument)**
- **Faster Validation (factor of 6) (EOS angular models)**

Where do I go for further CERES documentation?

- CERES Documentation/Home Page at http://asd-www.larc.nasa.gov/ceres/docs.html
- CERES Data Orders at http://eosweb.larc.nasa.gov/~latisweb